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Strategic use of IT in Radiology

A comparison between Sweden and the USA

Abstract

Information technology in healthcare is a hot topic both in the media, and for those who work in healthcare. Many experts argue the benefits that would be achieved by using IT more in healthcare. Within radiology there has been major efficiency and quality increases through digital imaging and information systems. This thesis examines how these information systems are strategically used in radiology departments in Sweden and the USA. The study shows that radiology is mature when it comes to use of IT and that productivity is high, but the use of digital technology alone, does not provide any competitive advantage to radiology. It does make it possible to run the business of radiology in new ways which could provide advantages. The real beneficiaries of the fast development of digital technology in radiology is society as a whole, and both Sweden and the USA have work in progress towards integration of systems nation-wide for healthcare in general.

Keywords: Strategy, Radiology, PACS, RIS, Competitive Advantage, Structured Reports

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Master thesis, 20 credits

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Introduction

IT (Information Technology) in healthcare is a topic of much interest in the media and effects healthcare in fundamental ways. The media has shown an increasing interest in IT in healthcare. In its March issue, BusinessWeek[1] devoted a special report to 'the digital hospital', bringing the benefits of information technology in healthcare to the surface. The article forecasts a boom in usage of information technology, and explains some benefits from that usage. IT in healthcare will change the way healthcare can be performed, boosting efficiency and quality in the business.

In particular radiology is referred to as a beneficiary[2] of the new technology and the part of healthcare that has come to integrate IT in their operations and have seen the benefits of its use.[3] There are many organizations working on developing the use of IT in healthcare by developing interface standards and forums for discussions amongst stakeholders, and in radiology the standard DICOM (Digital Imaging and Communication in Medicine) has made it possible to transfer and share images in a standardized format between systems and machines. Lundberg presented a doctoral thesis (2000) 'IT in Healthcare' at the Department of Informatics, Göteborg University.[4] She studied the design and implementation of PACS (Picture Archiving and Communication System) by understanding the radiological work practice and its links in detail. Her research showed a changing industry, moving from analogue imaging to digital imaging, allowing new processes and higher efficiencies. She found issues related to the people working in a changing environment, but an industry with lots of opportunities, if the issues were given attention.

There has been a broad implementation of digital systems at radiology departments in Sweden and the USA. Has this provided any strategic benefits to these radiology departments? This study compares radiology departments at some hospitals in Sweden and the USA to find out how they use IT and whether they do it strategically or not.

There has been a lot of research done on the technology, its implementations in radiology and the financial side of the new technology, but I have not found any research done on the competitive situation amongst radiology departments and how the technology is used in regards to that. Lundberg's[5] research focused on the softer sides of IT in radiology, to make the information systems better. She found that the developers of information systems for radiology often did not have enough knowledge about radiology and the vendors have listened to the users since. The information systems today are very usable and fit well into the workflow. Since this thesis studies more of the business side of IT in radiology, Lundberg's research was chosen not to be the theoretical base for the study.

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[1] Mullaney T., Weintraub A. (2005) *The digital hospital*
[2] Edmunds D., Khorasani R., Ros P. (2001) *Horizontal PACS deployment in an integrated system*
[3] Hurley G.D., Mcinerney D.P. (2001) *Going filmless in a new hospital setting*
[4] Lundberg N. (2000). *IT in Healthcare; Artefacts, Infrastructures and Medical Practices*
[5] Ibid.

To give the reader some basics of radiological work in general, and IT in radiology in particular, there is a section briefly describing this. It is NOT an attempt to cover details nor to be complete, but to give an understanding for the general situation and processes.

The aim of this study

Healthcare is organized in very different ways in Sweden and the USA, where most healthcare in Sweden is public and equal to all citizens, while healthcare in the USA is mostly through private insurance with different coverages.

IT is being used more and more extensively in radiology and provides for better efficiencies and higher quality care. It also changes the possibilities for new ways of doing business and sets the radiologists free from having to be physically present to view the images. Due to this new technology with the Internet as a catalyst, many industries have had to change and companies have had to adapt to a more competitive environment. It has become more difficult to be competitive and stay profitable. At the same time, healthcare is becoming increasingly more expensive, and is in Sweden a big problem for the government to deal with. As a result, hospitals in Sweden are reorganized and the regional governments have closed down some hospitals that are not considered to be financially justifiable. This would make it reasonable to believe that hospitals in Sweden compete to stay in business. In the USA most hospitals are private, and they compete more openly to get the business of patients.

Many IT professionals argue the strategic importance of IT and most companies IT budgets have become increasingly larger. At the same time there are discussions around the security issues with digital patient records and possible benefits from IT in healthcare. Does IT provide for different conditions of business competition in healthcare and is it used to become competitive?

Due to the limited timeframes of this study, and the limited resources, the aim of this study was only to investigate the possible strategic use of IT in radiology. It does not try to make any financial calculations, or financial comparisons between departments or countries.

The research question in this study is:

How do the radiology departments in this study use IT in strategic ways, and do they differ between Sweden and the USA?

When Nicholas Carr wrote his book "IT doesn't matter", it created some turbulence amongst people in the IT industry. Carr got a lot of attention and has been in the crossfire at conferences around the world. His bold statements caught my attention. Could it make any sense, what he said?

Radiology has been technologically well ahead and healthcare has also gotten a lot of attention in media lately. Looking at an industry like healthcare and radiology, paired with Carr's ideas, was a combination that was suitable for a study. To also add the dimension of comparing countries with such differently organized healthcare as Sweden and the USA, made it a perfect topic to study.

Method

Informatics is the science of information systems, not necessarily computerized systems, but the way information is used in a context and systematized. The aim of this thesis was to look at how the radiology departments strategically used information technology and put it in a business context. By performing a qualitative case study[6], I gained in depth knowledge in the way radiology is organized and the way they do business. It was important to understand how the information systems were used, and what they did in terms of adding value to the radiology departments. In addition to participative studies, several interviews where performed, as well as literature studies about research, radiology, technology and strategy.

By performing a participative study, I was given opportunities to interact with the staff of the radiology departments, in situations where practical problems presented conditions interesting for this study, that had been difficult to find with a quantitative study. I could also build a certain level of trust by listening to the staff as a pupil, making the staff feel more secure and possibly revealing more honest opinions. Radiology and healthcare are a complex business that require time to understand, and by participating in the day-to-day activities, an understanding of processes that are not described in the literature could be developed. In addition to the other methods of data collection, I took a computer-based training course in digital radiology. The choice of a case method was natural. Yin[7] states:

> *"A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context when the boundaries between phenomenon and context are not clearly evident and in which multiple sources of evidence are used."*

The usage of IT in radiology, and the strategic value of such usage, fit well into that description.

The aim was to achieve a holistic view of radiology and to put it in business context, so the study had to target a wide array of people and situations, and the findings throughout the study led to new aspects for the study. As a research philosophy the social constructivism was applicable, since the research area was wide, the situations studied consisted of human interaction in conjunction with computer systems, the data was rich and deep, and the participatory research allowed me to be part of different situations.

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[6] Easterby-Smith M., Thorpe R., Lowe A. (2002) *Management Research*
[7] Yin R. (1988) *Case study research: Design and methods*

Throughout the study, a research diary was kept, and the study evolved with new inputs from the situations studied. The findings from interviews, and situations observed sometimes needed clarification by the staff, and the reflections made by the author where verified with the staff. Some of the interviewees where extremely busy and would not allow recording of the interview, so some of the interpretations had to be verified through other people, weakening the reliability of the findings. It was sometimes difficult to get a hold of people who were responsible for the strategic decisions, and to get time with the radiologists. Radiologists are used to working by themselves and are very fast when interpreting images that to a layman are difficult to understand. They are also used to talking extremely fast when dictating, so when interviewing them, it was sometimes hard to keep up with taking notes, looking at the screen and understanding what they where saying.

The basic framework of this thesis was to start with a theory and apply it to real situations in order to verify the theory, but also to compare situations in the two countries studied as described by Easterby-Smith[8] as a 'case method'. The conclusions are specific to the hospitals and departments studied, but give a general indication of the situation of radiology in Sweden and the USA.

[8] Easterby-Smith M., Thorpe R., Lowe A. (2002) *Management Research*

How the study was conducted

The following radiology departments where part of this study:

- Radiology departments at two separate hospitals in Västra Götaland, Sweden. Both public hospitals, meaning they where part of the region of Västra Götaland, that organize the public hospitals in its region. Since they where both very equal in technology usage, size and part of the same organization, with the same goals, they are most often referred to as one entity in this study. As part of the Swedish hospitals, several meetings on a regional level where attended. (figure 1)
- The radiology department at a community hospital in the USA, providing healthcare to the citizens in the community. The hospital was owned by the community, until about one year prior to this study, when a large corporation acquired the hospital. (figure 2)
- The radiology department at a pediatric hospital in a large city, specializing in care of children. Additionally, a visit was made to the reading room where the radiologists worked nights, however it was located in a different part of the city. (figure 3)

The grey areas in the figures below indicate the studied parts of the organizations.

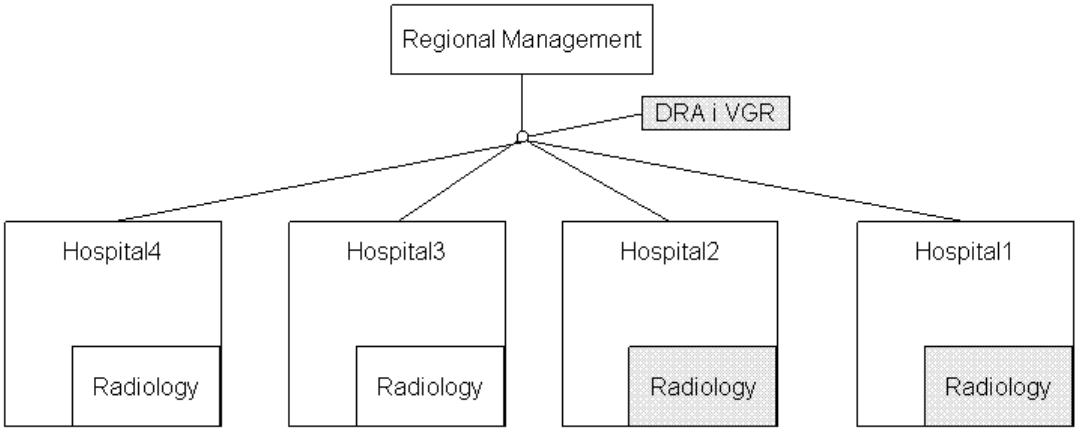

Figure 1 Organization of Swedish hospitals studied

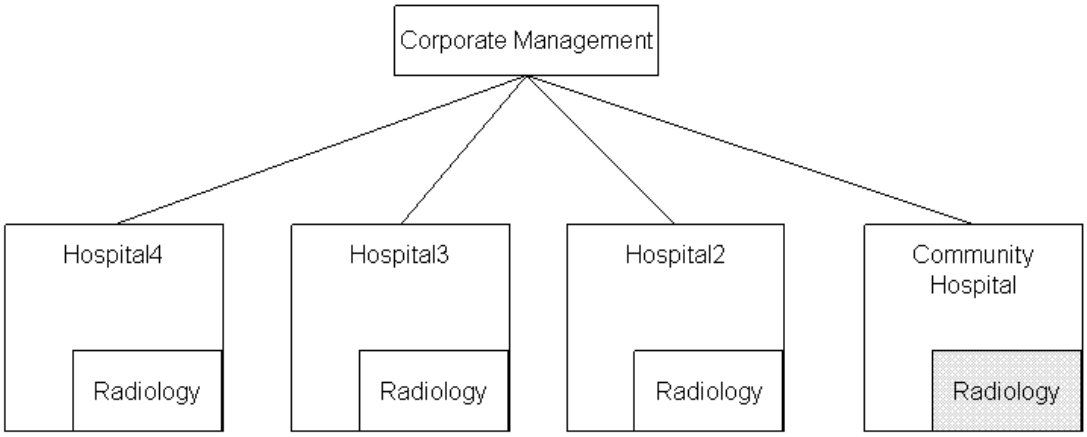

Figure 2 Organization of Community hospital in the study

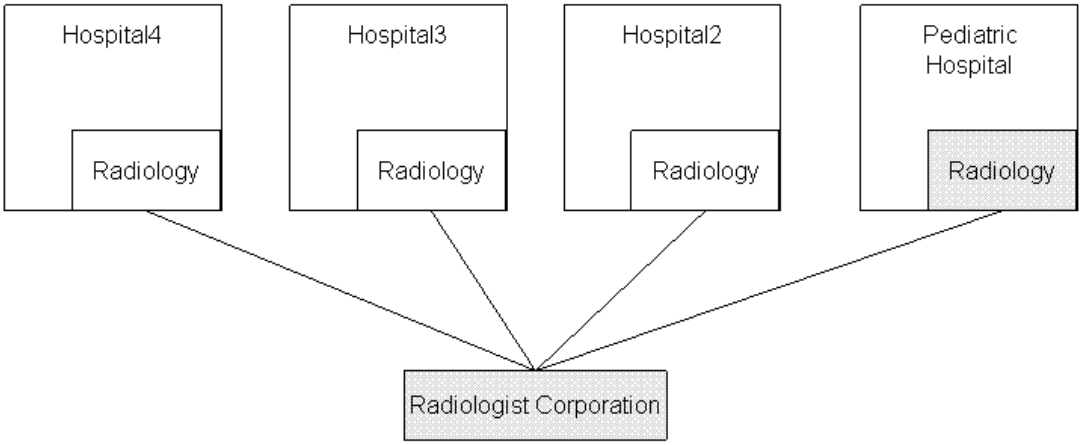

Figure 3 Organization of Pediatric hospital and Radiologist Corporation in the study

As a result of restrictions from the hospitals in the USA and sensitive findings, the names of the hospitals and even the states had to be kept out of this thesis. To treat the Swedish hospitals equally, I made the choice of keeping them anonymous as well. The US hospitals are therefore referred to as the Community hospital (owned by a corporation) and the Pediatric hospital (a hospital that specializes in care of children). The two Swedish hospitals were both public and part of the same region and had the same basic goal. The radiology departments at the four hospital where fairly equal in size and had around 80 employees each. In this thesis, the hospitals were chosen by the criteria that it would be possible to study different use of information technology, additionally it had to be practically feasible for me to spend some time at the facilities.

A full day was spent at each of the two hospitals in Sweden and people on different positions and different levels in the organizations were interviewed using unstructured and semi-structured methods. They were very helpful and explained the workflow and showed the information systems used.

In addition to being at the radiology departments, people on administrative and management positions were interviewed. The interviews were semi-structured and often resulted in many more questions, since the operations of radiology is very complex and most employees have very specialized tasks, with years of training for that specific task.

Extensive literature studies were performed as part of this study, with emphasis on digital radiology, PACS and standards in radiology.

The study performed in the USA was mainly located at the community hospital. Two weeks were spent participating in the operations and performing simple tasks to prepare for the future purchase of a PACS, such as collecting information on the computer network and capacity. Meetings about PACS were attended, and employees and managers in different positions were interviewed. The community hospital was the only hospital in this study that did not yet have a PACS.

Two days were spent at the pediatric hospital, plus one evening in the central reading room where the radiologists worked nights.

A large amount of data was collected which would require much more time than was available for this study, to analyze the findings thoroughly. The conclusions drawn are only valid for the departments studied, however a general pattern can be seen, which could apply for radiology in general, both in Sweden and the USA

What was studied

To get a thorough understanding of the radiological environment, several situations had to be studied.

First, a general understanding of radiology in a business context, was mapped with the help of Porters Value System and Value Chain. Then, the status of technological level and usage of formalized information systems was studied, in terms of IS Architecture, conceptual models, and integration of systems. All these situations were then related to strategy and compared between Sweden, the US community hospital and the US pediatric hospital.

Theoretical foundation

In this chapter I present general information on healthcare and radiology followed by a conceptual framework of theories, that will be used when discussing the results towards the end of the thesis.

The role of radiology in healthcare

As mentioned earlier, healthcare can be organized in different ways, from mostly public to mostly private caregivers, depending on the country. The organizations looked at in this study included two radiology departments at hospitals in Sweden and two radiology departments at hospitals in the USA. In Sweden, which is a socialistic country, healthcare is mostly public and all citizens are covered by health insurance. Most hospitals are run by the county organization and each county has its own political management that changes each election period. In the USA, healthcare is mainly private, with a foundation of private insurances. It is important for the individual to keep track of what the insurance covers and to go to the designated hospital or doctor. In general, competition is tough in business in the USA, and there is no reason to believe that it would be different in radiology.

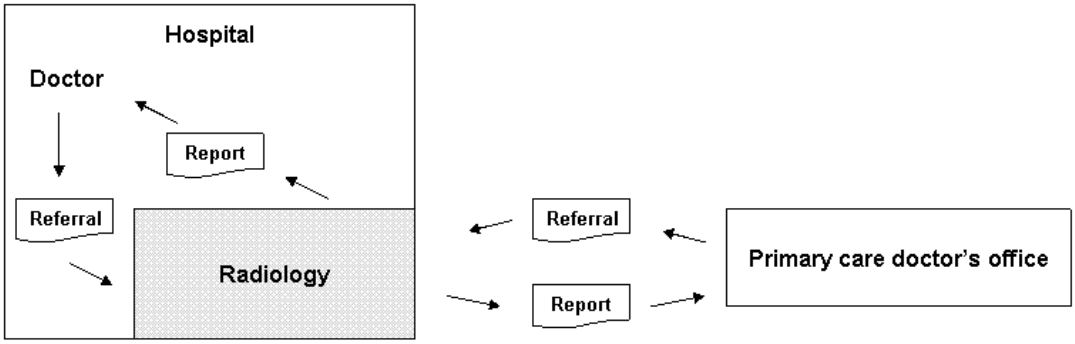

Figure 4 Description of radiology in reference to healthcare

Radiology is essentially a service provided for doctors in other fields of healthcare, either within a hospital, or for doctors outside the hospital. In the US this is referred to as inpatient or outpatient service. A study is performed using different technologies to capture an image of a part, or the whole body. The images are interpreted (read) by radiologists (Medical Doctors with radiology as a specialty) and a report is formulated for the referring physician (doctor). The images are often compared to previous images from the same patient, to see if any changes or abnormalities have taken place. The report is sent to the referring doctor, sometimes accompanied with the images, and the referring doctor can take appropriate action, depending on the findings. (figure 4)

Radiology explained

Traditional radiology meant images of the human body that were captured using x-ray technology and developing a film, much like analogue 35 mm film. The images were captured at different stations, called modalities, often referred to either by the technique used such as ultrasound, computer tomography (CT), magnetic resonance (MR) and positron emission tomography (PET), or the part of the body examined like chest and mammography. The technique used varied depending on what captured the best image for a certain examination. The film (image) was hung on a lightbox, so the radiologist could study the image, and then dictate a report, that was sent to the referring doctor.

Today many radiology departments use digital modalities instead of the analogue film. This is called digital radiology and these modalities produce a digital image, much like the small digital still cameras used by most people today.[9] To handle these digital images, and to handle the workflow and reports, a particular type of software is used. At the time of Lundberg's research[10], most hospitals in Sweden where just starting to use the digital technology and she wrote

> *"To make the diagnostic work more effective and to improve the services delivered, many radiology departments are planning to invest or are in the process of investing in Healthcare management systems, such as PACS and RIS. Briefly, PACS digitize and automate image acquisition, communication exchange and storage, while RIS digitize ordering, scheduling and the radiological patient record."*

In her research, Lundberg found that work at radiology departments focuses on streamlining workflow and that this is achieved by *"use of conventions, procedures and technologies"*. This standardization of processes[11] makes it possible for a doctor from any hospital to get up to speed in a new setting quickly. It also contributed to the development of standardized software.

PACS - Picture Archiving and Communication Systems - are examples of such standardized systems used for electronic storage, retrieval, distribution, communication, display and processing of medical image data.

PACS makes it possible for the radiologist to be physically separate from the patient (where the image is taken), by performing the reading (interpreting the image) on a computer screen, instead of as was previously done by looking at a physical image on a light box. The computer (workstation) where the image is displayed, can be located anywhere in the world, as long as it is connected in some way over a network in order to retrieve the image. This way of doing radiological work is referred to as 'teleradiology' and has made work much easier for many radiologists.

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[9] Hruby W. (2001) *Digital (r)evolution in radiology, introduction*
[10] Lundberg N. (2000) *IT in Healthcare, Artefacts, Infrastructures and Medical Practices*
[11] Mintzberg H. (1983) *Structure in Fives, Designing effective organizations*

Computerized Information Systems in Radiology

Essentially there are four types of information systems used at radiology departments using digital technology:

- Hospital Information Systems (HIS) - Provides information on the patients demographics and is the system used for billing and other administrative tasks. The HIS is usually used throughout the hospital and is the main system for keeping track of the patients with a unique Master Patient Record number, throughout the hospital.
- Radiology Information Systems (RIS) - The RIS is used for scheduling patients for exams, and creating worklists for the different modalities. It keeps track of the patients and shows when a study (exam) was started and when it was finished.
- Picture Archiving and Communication Systems (PACS) - The system where images are read (interpreted) and stored. It is also the system that often is connected to a web server, to provide viewing of images for the referring doctors, through a web interface.
- Modalities - The 'camera' where the image is taken. It has its own computer system to control the machine, how the image should be exposed, and the level of radiation to be used.

The different information systems are (most often) connected through a standardized interface, so information does not have to be entered multiple times. The figures below (figure 5 and 6) show how the different information systems in radiology are connected, and what standards are used. The first graphic indicates how it is currently functioning at many radiology departments, while the second graphic shows how it functions at some departments who are using the latest technology.

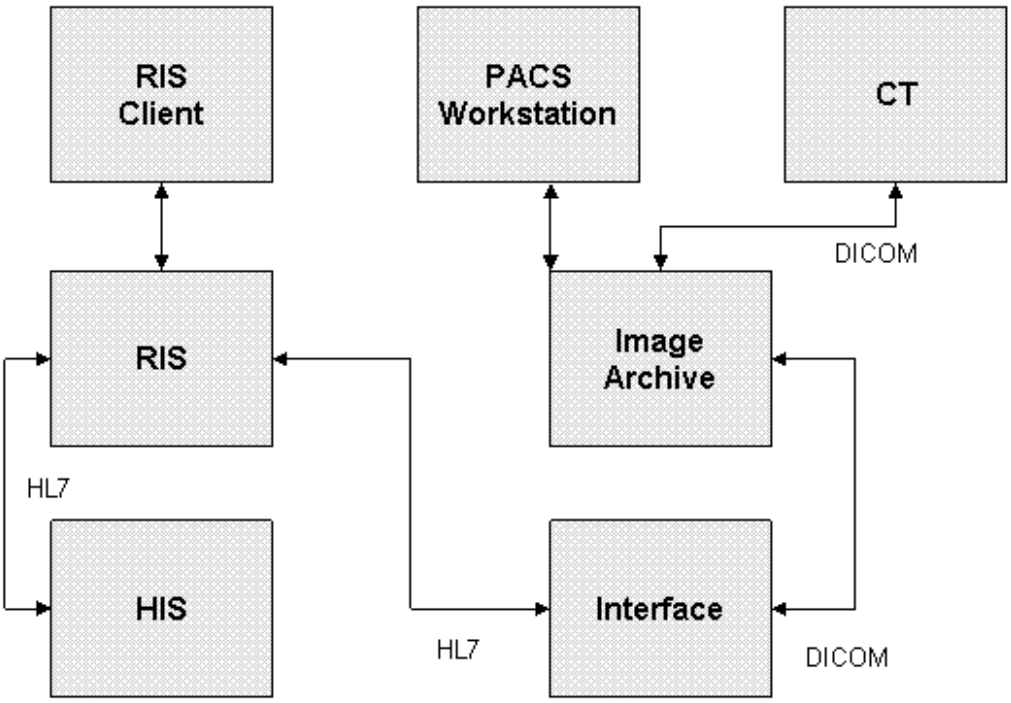

Figure 5 IS in radiology today

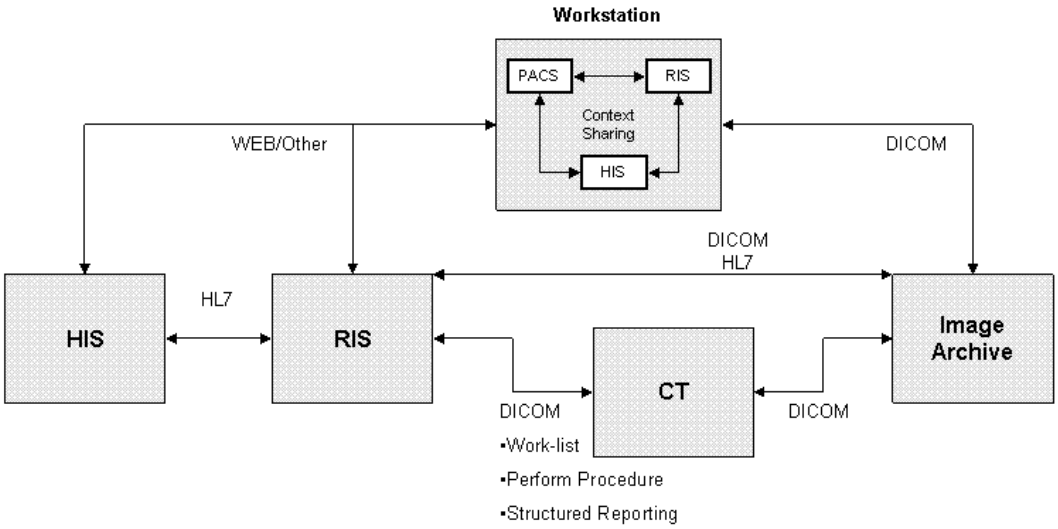

Figure 6 IS in radiology 'coming up'

Conceptual framework

To describe the information systems used in radiology, some of the conceptual framework suggested by Magoulas and Pessi[12] in their doctoral thesis is used. I will briefly present the parts that I wish to use. For a full description, I refer to their book.

With so many information systems in an organization, there would likely be a problem when connecting all these information systems. Magoulas and Pessi suggest a common terminology for architectural IT management, where they define different levels of integration of systems (figure 7). They define four levels of integration as unified systems, overlapping systems, interlinked systems and independent systems.

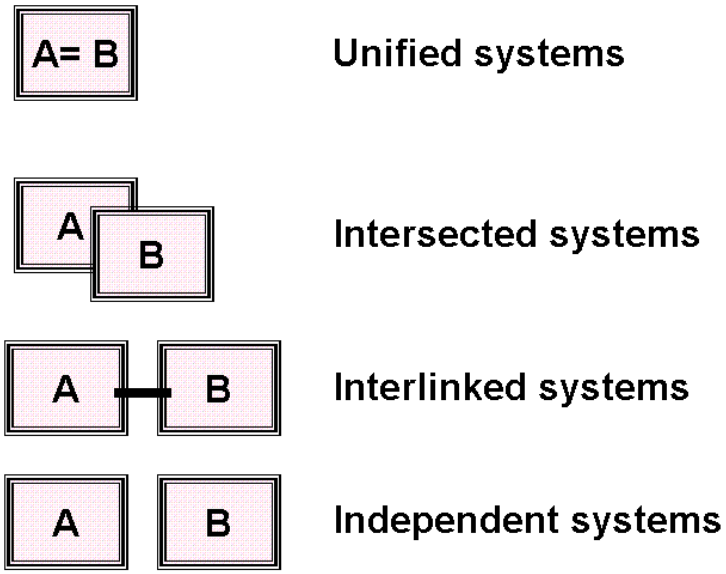

Figure 7 Integration models by Magoulas and Pessi

To understand how the information systems are connected in radiology I will refer to these types of integration models.

Magoulas and Pessi[13] believe that there is a lack of common terminology in IT management, with well defined meanings. They criticize the use of ill-defined words with fuzzy meanings and suggest a framework for IT Management. One important word is 'information environment', which reflects quality requirements related to the organizational and social reality. It also reflects the mutual relationships between information domains. For information technology to be a means for success, people working within the Informatics area need to achieve a better knowledge of how people build social architectures. They mean that people have mental models, with

[12] Magoulas T., Pessi K. (1998) *Strategisk IT Management*
[13] Ibid.

conceptions, knowledge and values, that reflect the social architecture and our differences.

They mean that formalized information systems can be described in terms of a conceptual model and an information processor. The conceptual model (figure 8) consists of conceptions (terminology), information and rules; and the information processor consists of computer software and computer hardware.

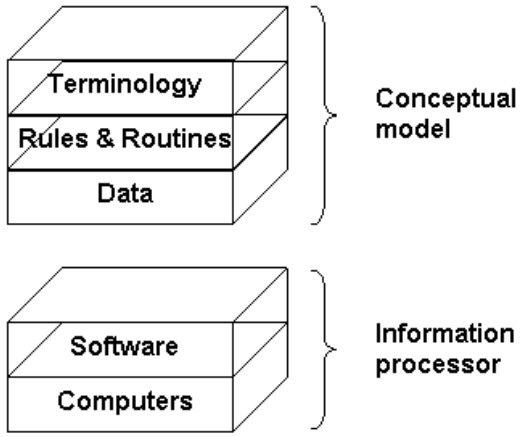

Figure 8 Conceptual model by Magoulas and Pessi

When connecting so many information systems as they do in radiology, there can be an issue of having a common terminology throughout the organization/organizations.

Porter's ideas on Competitive Advantage

Porter presented his ideas about the Value Chain in his book 'Competitive Advantage' in 1985.[14] It describes how companies develop a competitive advantage and shareholder value through separating the business systems into a series of value-generating activities, referred to as the Value Chain (figure 9).

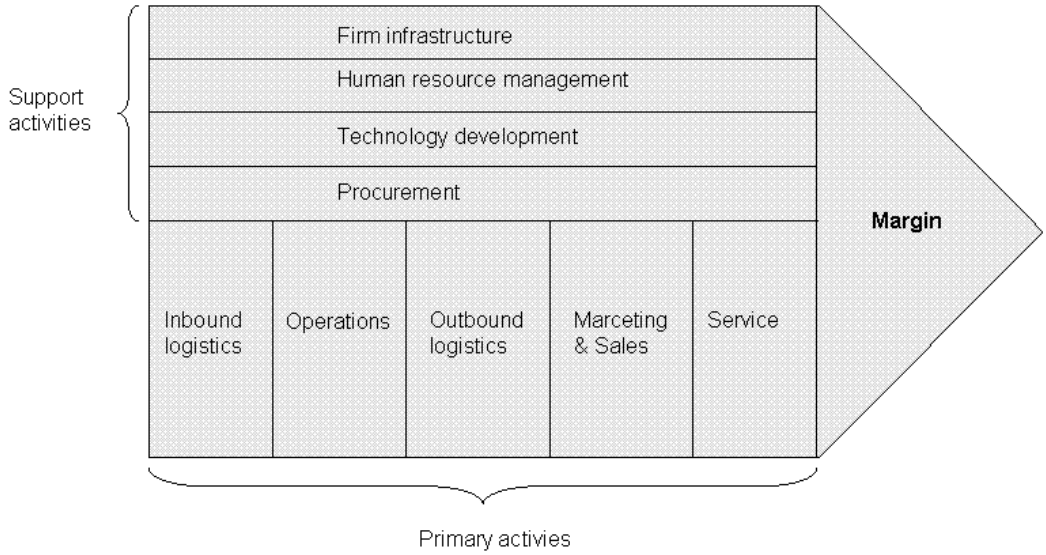

Figure 9 Value Chain by Porter

There are primary activities and supporting activities. The primary activities are:

- Inbound logistics - the receiving and warehousing of raw materials, and their distribution to manufacturing as they are required
- Operations - the process of transforming inputs into finished products and services
- Outbound logistics - the warehousing and distribution of finished goods
- Marketing and sales - the identification of customer needs and the generation of sales
- Service - the support of customers after the products and services are sold

The supporting activities are:

- Infrastructure of the firm - organizational structure, control systems and company culture
- Human resource management - employee recruiting, hiring, training, development, and compensation
- Technology development - technologies to support value-creating activities
- Procurement - purchasing inputs such as materials, supplies, and equipment

[14] Porter M. (1985) *Competitive Advantage*

A company's profit depends on its effectiveness in performing these activities efficiently, so the amount the customer is willing to pay for the products (services) exceeds the cost of the activities in the value chain. The company has the opportunity to generate superior value in these activities and a competitive advantage may be achieved by changing the configuration of the value chain, to provide lower cost or better differentiation. Even though the value chain is targeting manufacturing companies, it can be applied to all business, even healthcare and radiology. Porter means that when outsourcing, a company should outsource the supporting activities, but keep the primary activities in house.

Figure 10 Value System by Porter

When putting several Value Chains together, Porter calls this the Value System[15] (figure 10), where the company's Value Chains is part of a stream of activities, where Value Chains are found both prior to, as well as after the company's Value Chain. This helps understand the value a company provides in a customer's Value Chain. Radiology is put into such a Value System, and related to what is provided.

[15] Porter M. (1985) *Competitive Advantage*

Strategic use of IT

To discuss the strategic use if IT in radiology, there must be a clear definition of the word strategic. Roget's Thesaurus[16] from Random House provide the following definition of strategic:

> *"1. Tactical, military; calculated; political, diplomatic; planned, well thought-out, deliberate, clever, cunning, cautious, careful, guarded, prudent, precautionary, vigilant, wary. 2. crucial, important, decisive, critical, vital, significant, momentous, key, principal, consequential, turning"*

And the Merriam-Webster[17] online dictionary gives the following description:

> *"Function: adjective*
>
> *1 : of, relating to, or marked by strategy <a strategic retreat>*
>
> *2 a : necessary to or important in the initiation, conduct, or completion of a strategic plan b : required for the conduct of war and not available in adequate quantities domestically <strategic materials> c : of great importance within an integrated whole or to a planned effect <emphasized strategic points>*
>
> *3 : designed or trained to strike an enemy at the sources of his military, economic, or political power <a strategic bomber>"*

The word strategic seems to have developed differently in business. In this thesis, I will follow Porter's way of using strategic. In his book Competitive Advantage, Porter presented three generic strategies to gain competitive advantage:

- Cost leadership - by offering the same product or service as the competitors, but doing it at lower costs
- Differentiation - by selling something different than the competitors
- Focus - by targeting a specific group of customers, or a specific area.

[16] Random House (2001) *Roget's Thesaurus*
[17] www.m-w.com

He developed these thoughts in an article in the Harvard Business Review[18] in 1996 where he discusses operational effectiveness and strategy. Porter means that even though there are fast changing markets and some barriers to competition are disappearing, it is dangerous to only look at core competencies and to outsource in order to be efficient. He states that it is essential to distinguish between operational effectiveness and strategy.

> *"Operational effectiveness (OE) means performing similar activities better than rivals perform them. Operational effectiveness includes but is not limited to efficiency. It refers to any number of practices that allow a company to utilize its inputs by, for example, reducing defects in products or developing better products faster. In contrast, strategic positioning means performing different activities from rivals' or performing similar activities in different ways."*

Porter describes 'the sum of all best practices of an industry' with the technical development as a "productivity frontier". That would be the maximum value an organization could deliver (product or service) with a given cost, using the best technologies, skills and management techniques. He means that this productivity frontier is constantly moving outward, with the development of new technologies. Organizations with poor operational effectiveness, who are not at the frontier can increase their performance greatly. It is necessary to constantly improve the operational effectiveness, to achieve superior profitability, but not enough to make it sustainable, according to Porter. He suggests three distinct sources of strategic positioning to gain sustainable profitability:

- Variety-based positioning, where a company produces a subset of an industry's products or services. It is a choice of product or service, rather than customer segments.
- Needs-based positioning, where a company can serve most, or all needs of a particular group of customers.
- Access-based positioning, where a company chooses to serve customers who are accessible in different ways, whether by geography or customer scale.

In this study, radiology is put in the context of the value chain and the productivity frontier in radiology is studied in terms of the technological development.

[18] Porter M. (1996) *What is Strategy?*

IT doesn't matter

Carr[19] presented an article with this controversial title in the Harvard Business Review and discusses the strategic importance of IT. He means that in the past Chief Executives did even not use a keyboard, but today they think of IT as a strategic resource and consider how to leverage their IT investments for differentiation and advantage.

> *"Behind the change in thinking lies a simple assumption: that as IT's potency and ubiquity have increased, so too has its strategic value. It's a reasonable assumption, even an intuitive one. But it's mistaken. What makes a resource truly strategic - what gives it the capacity to be the basis for sustainable competitive advantage - is not ubiquity but scarcity. You only gain an edge over rivals by having or doing something that they can't have or do."*

Carr compares IT to technologies like the steam engine and the telegraph and means that IT is essential to everyone, but does not provide any distinction to anyone. Carr also says that technology tends to be standardized as best practices and is built into the infrastructure itself and compares this with factories having electric outlets built in and uses electricity as a commodity. The only benefit being a cost advantage that is hard to sustain.

According to Carr, technology influences competition on a macro economical level instead of the individual company. He means that companies have to rely on the country to harness the power of technology to gain full benefits of the technology. Carr says that it is possible to gain competitive advantage by using proprietary IT early on in the development of the technology, but within ten years, due to 'best practices' being built into the software, it will be difficult to sustain that advantage.

Within radiology there are few departments today that do not use, or plan to use PACS and digital technology. Some hospitals and regions were early to adopt the new technology and paid large amounts of money for their systems, but today the cost of such systems has fallen and is affordable to most hospitals. So how do radiology departments use, or plan on using that technology, and what strategic value does it have?

[19] Carr N. (2003) *IT doesn't matter*

Empirical result

The study aimed to capture a holistic view of IT in radiology and a large amount of data was collected. Throughout the study the following participative studies and interviews where performed:

Table 1 Number of days of participative studies and interviews performed

	Participative studies	**Interviews**
Swedish hospitals and regional meetings	4 days	4
US Community hospital	8 days	8
US pediatric hospital	2 days	2
PACS/RIS vendors in Sweden	0 days	2

The table above shows the number of days of participative studies, and organized sit down interviews at the different hospitals. On top of these interviews, a number of shorter interviews were conducted during the participative studies at the departments.

General findings about IT in radiology

The work with digital technology and the wish to being able to share images across hospitals and between radiology departments, has driven the development of standards for images. There are several standards, and many organizations continuously work to expand these standards and make it possible to share information in even better ways. The way the information systems were integrated in radiology could be described with Magoulas and Pessi's[20] terminology as being systems with intersections, i.e. they shared certain elements, eliminating duplicates.

As mentioned in the background, DICOM is used to communicate images and image related information. The other important interface standard is HL7 (Health Level 7), used to communicate textual information.[21]

DICOM, developed by the American College of Radiology and the National Electrical Manufacturers Association, defines a uniform and well understood set of rules for communication of digital medical images. It allows a seamless transfer of images and related information between modalities and RIS/PACS. It also provides a standardized interface for putting the information and images on a CD, together with a DICOM-viewer (a software tool used to view and edit images in the DICOM format), that can be sent to referring doctors. Some patients with serious health issues

[20] See section on intergration models
[21] Piraino, D. (2001) *Radiology information system and picture archiving and communication system: interfacing and integration*

can also carry a CD with their images, to provide quick access to the images when traveling, in case of sudden changes of their health.[22]

A supplement to the DICOM standard, Structured Reports[23], was recently developed, making it possible to put the report (the findings from the images) in a standardized format together with the image. Having the reports in a standardized format would help research new and better knowledge.[24] At the same time it would limit the individual creativity of the radiologist, when designing the report, which will not be popular amongst the radiologists.[25] There are also problems associated with the implementation of the Structured Reports by the vendors of PACS and RIS, most likely delaying the practical use of Structured Reports.[26]

HL7 is a set of standards used to transmit text-based data between systems, focusing on exchange of information within organizations. The HL7 standard has been used mainly for the interface between HIS (Hospital Information System) and RIS (Radiology Information System). Often there are interface systems translating between the HL7 and DICOM standards between RIS and PACS. Work is in progress to implement both HL7 and DICOM for communication between RIS and PACS, to eliminate the need for interface systems.[27]

Some PACS and modality vendors (like GE) have tried not to use the standards, or only to use a subset of the standards, to complicate compliance between modalities by other vendors and the PACS vendors, in order to sell more modalities. This has failed, due to boycotting of such vendors, and forced them to comply with the standards.[28]

RSNA (Radiological Society of North America) each year hosts a conference, that although it is a US organization, attracts people and organizations from all over the globe. Information technology has been a very hot topic for many years at these conferences, and discussion groups have been formed with both vendors and users participating, to drive the technology forward.[29] There is a fast progression of information systems like RIS and PACS. They are developed on platforms that are the same for all regions, and then nationalized according to language: This does not allow for any major differences in workflow and practice.[30]

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[22] Interview with PACS administrator at pediatric hospital.
[23] Clunie D. (2000) *DICOM Structured Reporting*
[24] Interview with manager A at Swedish hospital
[25] Interview with radiologist K at Swedish hospital
[26] Interview with manager A at Swedish hospital
[27] Piraino, D. (2001) *Radiology information system and picture archiving and communication system: interfacing and integration*
[28] Interview with manager D at community hospital
[29] www.rsna.org
[30] Interview with representatives for RIS/PACS vendors Agfa and Sectra

Benefits of PACS

The evolution of enhancements in technology has had great impacts on radiology, mostly due to radiology's heavy reliance on imaging processes, techniques, and equipment. Several benefits are achieved by using digital radiology and PACS, in combination with integration of HIS and RIS. Direct cost savings can be achieved thanks to less film being used, less work with filing and retrieving images and fewer images lost. There are also indirect benefits like improvements in efficiency, productivity, workflow, enterprise integration, and quality of care. Additional benefits include images being available to the referring doctor more rapidly, patients being exposed to less x-rays when image quality increases, better research opportunities when large amounts of images are available over large networks, and better teaching situations when images can be neutralized of personal data and made available across networks.[31]

[31] Edmunds D., Khorasani R., Ros P. (2001) *Horizontal PACS deployment in an integrated system*

Standardization throughout healthcare

Not only has there been a lot of work done to standardize interfaces within radiology, but organizations like IHE (Integrating the Healthcare Enterprise) are doing work to achieve better integration throughout the healthcare enterprise.
On IHE's website they write:

> *"IHE is an initiative by healthcare professionals and industry to improve the way computer systems in healthcare share information. IHE promotes the coordinated use of established standards such as DICOM and HL7 to address specific clinical needs in support of optimal patient care. Systems developed in accordance with IHE communicate with one another better, are easier to implement, and enable care providers to use information more effectively. Physicians, medical specialists, nurses, administrators and other care providers envision a day when vital information can be passed seamlessly from system to system within and across departments and made readily available at the point of care. IHE is designed to make their vision a reality by improving the state of systems integration and removing barriers to optimal patient care"*[32]

IHE hosts conferences where stakeholders from organizations around the world meet to share experiences and help drive the development of integration within healthcare. There is also a Swedish initiative, similar to the IHE initiative, addressing the issues related to the Swedish implementation of standards and integration.

In addition to IHE, the organization HIMSS (Healthcare and Information Management Systems Society) provides "*leadership for the optimal use of healthcare information technology and management systems for the betterment of human health*".[33] They are also a stakeholder with many members, and focus on the development of healthcare informatics. They developed a definition of interoperability as:

> *"Interoperability means the ability of health information systems to work together within and across organizational boundaries in order to advance the effective delivery of healthcare for individuals and communities."*[34]

[32] www.ihe.net
[33] www.himss.org
[34] www.himss.org/content/files/InteroperabilityDefinitionBackgrounder.pdf

National standardization of terminology

When connecting information systems, there is a need for using the same terminology, to have the same conceptual model[35], so the information that is put into the systems is consistent. There are several projects to achieve this consistency.

In healthcare there exists an international standard for terminology called SNOMED (Systematized NOmenclature in MEDicine)[36], and in Sweden there are similar standards provided by Socialstyrelsen (SOS)[37], but it is not enough to provide a common terminology throughout healthcare. In addition to the above organizations, there are many others who compete to influence the development of such standards, with their own agendas. The Swedish 'codes' provided by Socialstyrelsen are used at most hospitals, but most hospitals have defined their own codes on top of the ones from Socialstyrelsen, with the result that it is impossible to perform searches amongst the reports and get reliable results.[38]

Within both countries work is being done to standardize the terminology used and the formatting of data in the information systems.

In Sweden, there are two organizations working with slightly different parts of the problem. Standardization of IT infrastructure is done by Carelink[39], and the conceptual model (terminology), by InfoVU.[40]

Carelink is a joint venture with Landstingsförbundet, Svenska kommunförbundet, Föreningen Vårdföretagarna (formerly Privatvårdens Arbetsgivarförbund) and Apoteket AB. Socialstyrelsen gives its support through a cooperation agreement. Carelink is a membership organization where counties, regions, municipalities and private caregivers are invited to be members.

InfoVU is a project run by Socialstyrelsen, Landstingsförbundet and Svenska Kommunförbundet and works with standards for terminology and conceptions as well as enterprise development. The project is supposed to deliver a report to the government in the spring of 2005, but the implementation across the country will be some time in 2006.[41]

The work towards one Medical Patient Record for each patient in Sweden has several issues to resolve. There are several laws making it difficult to share medical records with a lot of administrative bumps along the way. The digital medical record, has to obey the same laws as a physical medical record, making it difficult to utilize the benefits of the digital technology. The existing differences in terminology used are also a problem that slows down the process. Until recently there has also been a lack

[35] See section on conceptual model
[36] www.snomed.org
[37] www.sos.se
[38] Interview manager C at Swedish hospital
[39] www.carelink.se/pages/oneRightPicture.asp?VersionID=1&Pages=1,2
[40] www.sos.se/Hs/storproj/inf.htm
[41] Interview with Inger Weijerfelt, InfoVU

of coordination of the implementation of technology in the different regions and municipalities. As a result of this work, there are three solutions suggested, which are currently being discussed:

- The patient is responsible for his/her own medical records on a smart card, or a safe web site.
- A decentralized model, where the records are kept in the different local systems that exist, and should be accessed through VPN (virtual private network) or over a WAN (wide area network).
- A central model, where information is being 'dumped' from the local system to a central system, in a standardized format.

All three have issues related to the law, security, ethics, consistency and reliability. Before any decision can be made about such digital medical records, there has to be a thorough debate about all issues, which will take time.[42] The same discussion is going on in the USA, where they have the same alternatives, but also the problem that most hospitals are private.

In the USA, work on standardization is (mainly) done by the National Committee on Vital and Health Statistics (NCVHS), but there are many stakeholders and organizations who want a say in this development. Standards Insight writes the following about NCVHS:

> *"...National Committee on Vital and Health Statistics (NCVHS) is analyzing codes and vocabularies in order to make recommendations to the Secretary of HHS, addressing the creation/promotion of national terminology standards for Patient Medical Record Information (PMRI). This is part of a larger undertaking by the NCVHS to study the issues related to the adoption of uniform data standards for PMRI and the electronic exchange of such information, as mandated by the HIPAA legislation of 1996. One recalls that NCVHS made similar recommendations in regards to PMR messaging standards in February 2002. Interestingly NCVHS' charter does not define the EHR/PMR or its purpose."*[43]

The HIPAA (Health Insurance Portability and Accountability Act) is a law in the USA that defines necessary security actions to take in the health industry. It has put a lot of pressure on healthcare institutions to have a high level of security control in their business and information systems.[44]

[42] Nymark M. (2004) *IT i vården*
[43] www.himss.org/content/files/StandardsInsight/2003/07-2003.pdf
[44] Frantz K. (2003) *How much security is enough, when it comes to HIPAA*

Findings from Sweden

Since both hospitals studied in Sweden were public hospitals, run by the region of Västra Götaland, they had a common goal of serving the people as part of the public healthcare. There was a central decision to purchase a system that will enable radiologists at one hospital to view images taken by a different hospital in the region[45], a project named Distribuerat Radiologiskt Arbete i Västra GötalandRegionen (DRA i VGR), meaning distributed radiological work in the region of Västra Götaland.

Both hospitals' radiology departments where operating filmlessly, using both PACS and RIS and had them well integrated. Demographic and other information about the patient was seamlessly transferred between the HIS, RIS, PACS and modalities. They even had a 'rounds' module, which integrated RIS and PACS on a workstation, developed for the Swedish hospitals by the PACS producers, for rounds where referring doctors would come to the radiology department, and the radiologists would have created a list of patients referred by the visiting doctors. The images of these patient would then be projected on to large screens, where the radiologists would go through and show what they could see on the images. With such a procedure the referring doctors were given opportunities to ask additional questions and get feedback on their referrals, constantly educating the referring doctors.

This way of doing rounds with referring doctors is a particular Swedish way of working[46], and was not used at all at the community hospital, or at the pediatric hospital. The rounds module integrated the RIS and the PACS, and provided the ability to create work lists for the rounds. At both Swedish hospitals, the radiologists were using three monitors, where the RIS was showing on the left screen and the PACS showed the old images on the middle screen and the newer images on the right screen, compared to mostly only two monitors, with only PACS at both US hospitals.

The purpose for going filmless and digital in Sweden, was mainly to gain operational effectiveness and increase the quality of the radiological work, but also necessary to stay competitive. According to a manager at one of the hospitals, the outcome of going filmless certainly has made them more efficient and they have been able to save some money by having fewer employees.[47] According to the same manager, the other hospital in the study was still employing the same number of employees, and commented that there might be political reasons for not laying off people. At the time of this study, one of the Swedish hospitals was starting an evaluation process of voice recognition for dictation. The attitude amongst the radiologists was somewhat hesitant. They believed that it put too much pressure on the radiologist, to also be good at formulating text in a readable and consistent way. When they were dictating and someone else was transcribing what they said, often the transcriptionist corrected the language, so the report would be easier to read.

[45] Meeting with DRA i VGR
[46] Interview with radiologist K at Swedish hospital
[47] Interview with manager A at Swedish hospital

One of the Swedish hospitals had a hard time finding radiologists, and one way of dealing with this shortage of doctors was to use the service of viewing images, provided by a group of radiologists located in Barcelona, Spain. The group in Spain provided service for several hospitals in Scandinavia and the United Kingdom. They use the fact that there is a shortage of radiologists in those countries, but a surplus of radiologists in Spain.[48]

One of the managers in Sweden said that there had been discussions about creating a central reading room within the region of VGR, but he believed that the future is too unknown to invest in such a room.

> *"Today cardiology perform most radiological work at their own department themselves and perhaps there will be other departments taking over their part of radiological work in the future, this is why it could be unwise to make a major investment that might be useless in five years."*[49]

According to him there is a need to analyze where in the Value Chain radiology is located, and that there is a lack of such thinking amongst management today in the region. He also believes that because the software developers build database models, that are a base for information systems used by healthcare professionals, the systems are often built with different terminology and functions than what is actually used in healthcare.

Some Swedish hospitals had started to use a web-based form for referrals from doctors outside the hospital, which meant that the radiology departments would get the referral information directly into their systems. Apparently there were some problems with the integration of these forms at the time of my study, so I could not see how they functioned.

Regional project, DRA i VGR

The project DRA i VGR has the goal of connecting the radiology departments at all the public hospitals within the region of Västra Götaland, making it possible for radiologists at one hospital to view images acquired at another hospital. This way the hospitals would be able to 'loadbalance' the radiological work within the region. As part of the preparation for the project of DRA i VGR, one of the hospitals in the region made a financial analysis of what they would gain by going filmless.[50]

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[48] Bohlin S. (2005) *Röntgen i Spanien*
[49] Interview with manager C at Swedish hospital
[50] Lundgren G. (2004) *PENG-Analys, Digital Röntgen*

Findings at the community hospital in the USA

The community hospital was owned by its community until about a year prior to this study was carried out. The community then sold the hospital to a for-profit-corporation with around 80 hospitals in its portfolio. The reason for the sale was the need for additional heavy investments and the lack of capital for such investments.[51]

The radiology department at the community hospital produced vast amounts of paper and film, which were filed in a file-room. This was very different from the Swedish hospitals, where very little paper and film was used. The information systems used were a HIS, RIS and some digital modalities, but the HIS and RIS where poorly integrated and some information had to be typed in several times into the different systems. They did not yet have a PACS, but did have some modalities producing digital images, such as Nuclear Medicine, MR and CT. The images from MR where stored locally on tape by the modality and required lots of labor to retrieve old images. The images from Nuclear Medicine where also stored locally, but on CDs. From CT they actually printed images that where all archived in their large file room together with film from all the other modalities. All images that were digital were 'read' (interpreted) by the radiologists on screens, which definitely was the preferred method for reading.

They did have a HIS (Hospital Information System), which was new to them, since they where acquired by the corporation. The employees were not totally happy about being forced to using this system and the manager of the IS department said:

> *"It is like being thrown back two years in time, since this (new) system doesn't handle many of the functions our old system did, but it is definitely the way to go for a large corporation. They need to have the same systems at all hospitals to not kill themselves. I had done the same if I was the CIO on corporate level."*[52]

When interviewing employees working with the new HIS, it became apparent that the new HIS, which the corporation had installed, had created some problem for the users. Reading between the lines, it was obvious they had opinions they did not dare to say in fear of losing their job. Some of the employees even said straight out that they believed that they would get fired for saying what they said to me.

Even though they did not yet have a PACS for storing the images, they had found a practical use of the digital images produced by the MR and CT modalities. Apparently there was a shortage of radiologists in rural areas in the USA and the hospital had a hard time attracting radiologists. One of the downfalls of being a radiologist is that you have to be 'on call' and go to work at night when there are emergencies requiring radiological work. Since it is stressful for the radiologists not knowing when they have to go to work at night and the large number of nights they

[51] Interview with Gilbert L. (previous board member at community hospital)
[52] Interview with manager E at community hospital

have to be on call, this is something they want to avoid. It is also expensive for the hospitals to have the radiologists come in at night.

As a benefit both for the hospital and the radiologists, they used something called a 'nighthawk service' in Australia. Nighthawk is a general term used for radiological service provided over a network (also called teleradiology), where the radiologist is at a different location, during the hours of the night. Due to the time difference between the US and Australia, there is daytime in Australia when there is night in the US. Through a VPN (Virtual Private Network) the radiologist in Australia was working daytime hours, reading images and writing reports, at a lower rate than the radiologists on call in the US, providing financial benefits for the hospital. In addition it made it more popular to work at that hospital for the radiologists, since they didn't have to work so many nights.

As a smaller project before the PACS implementation, they planned on acquiring CR (Computed Radiology), where the image is exposed on a phosphor surface and then digitized in a machine, making it possible to edit the image digitally. It also makes it possible to view and store the image digitally. The main purpose was to provide access to the digital images temporarily for the referring doctors, so the images would be available to the referring doctors through a web interface for a short time after the images where taken. The images would still be printed on film and archived physically long-term. In the USA, images have to be archived for seven years before they can be destroyed.

At an interview, the radiology department manager at the community hospital expressed issues with going filmless:

> *"Many of the referring physicians do not even know how to use a computer, and it would create serious problems for them if we told them that they had to use a computer to view the images"*[53]

The managers on the 'corporate level' had mentioned that when they where implementing PACS, there would be no more printing of film. This indicated that the department manager would have to deal with practical issues, the people that the corporate headquarters never saw.

[53] Interview with manager D at community hospital

Measuring productivity

Corporate management delivered reports on the productivity[54] every week to the department. These reports measured how many exams had been done the previous week compared to a theoretical optimal number of exams, and discussions took place to find out the reason for any discrepancies. The optimal number could change without prior notice from the headquarters, which caused some turbulence among the staff. Changing numbers, by which people are judged, without prior notice, indicates a Tayloristic[55] view of the organization and might cause tensions between the company and its employees. Many employees felt great distance between 'the corporate people' and themselves. They where also concerned with the security of their employment, limiting what they wanted to reveal in the study.

As stated previously, healthcare in the USA is mainly based on private insurances that have different coverage with different caregivers, depending on which insurance plan the individual has. During the study at the community hospital one of the radiology technicians[56] explained:

> *"When a patient gets here, we check so the procedure is covered by their insurance plan. It is done at the time of reservation, at registration and before the procedure is done, so we know that we get paid. We compare the procedure code with the list of insurances."*

The lists he talked about were printed lists that were updated a few times every year. The insurance systems were not at all integrated with any of the information systems used at the radiology department.

Apart from the move towards a PACS, there was a discussion about voice recognition systems amongst the department manager, and the radiologists. The radiologists were very negative towards such a system, and said they would not accept the hospital getting one. The reason for this, was the same as what the radiologists in Sweden said, that they would have to think about dictating in a more readable language, which they said they could not do.

[54] Waters D. (2002) *Operations Management*
[55] Hatch M.J. (2002) *Organisationsteori*
[56] Comment by radiology technician at community hospital

Findings at the pediatric hospital in the USA

The pediatric hospital was very similar to the Swedish, in that they where completely filmless, i.e. used digital modalities and stored the images on a PACS. They also used a voice recognition system for dictation, i.e. the radiologists talked into a microphone, and the text popped up on the screen for review immediately. This way they were able to cut the time for a patient arriving at the radiology department, to signed report, from 3.9 hrs to 1.3 hrs. Additionally, they where able to bill much faster than previously. The radiologists at the pediatric hospital where very happy with the voice recognition system, and said it was very easy to use and trainable if someone spoke in a way difficult for the system to interpret.

They were constantly working on increasing the workflow efficiency making the work-environment better for all employees and cutting costs, according to the person responsible for PACS and other information systems at radiology. They felt that they had to have great systems and workflows to be efficient, but also to attract the best staff. The competition for the best staff was tough in that city.

The radiological work (viewing of images and creation of reports) was performed by an outside company with radiologists servicing several hospitals in the same city/region. The radiologists from that company were doing the reading (viewing) at the hospital during the day, but had a central ‘reading room’ where two radiologists were working every night, reading images from all the hospitals the company was servicing. This group of radiologists aimed at being very fast, and providing radiologist service with a specialized radiologist, to keep an extremely high quality of their work. This was possible to achieve by organizing about 70 radiologists within the company, and having an extensive Intranet, where they added their own rules, routines and documentation on particular difficult studies (images). At the central ‘reading room’, they had to work with several different PACS, on several different PACS work stations set up in a large room. The group of radiologists had a very relaxed atmosphere and were very fast to communicate with each other over the phone, when they had issues. Because they were so many radiologists, they developed specialized knowledge of different part of the body, or different types of exams, but shared experiences with each other through regular meetings where they discussed how to express certain findings in a standardized way in the reports. One of the radiologists said that he could most often not determine who in the group had written a particular report, due to the standardization they had achieved in the group.

To work with many different PACS at the same time, was not a major problem for them, but one radiologist expressed a wish for a different setup:
"If all vendors actually used the existing standards completely, it would be possible for each of us to use the PACS of our choice, to read images from all hospitals on the same station, making us even faster and doing fewer mistakes"[57], indicating that the vendors do not actually fully follow the standards. He also explained that the competition of reading images was not necessarily from other large groups of radiologists, but from smaller offices, who could 'cherry-pick' to view only MR and CT, which they could charge higher fees to read.

[57] Interview with Radiologist M at pediatric hospital

Summary of findings

In Sweden, there are several projects in the pipeline to standardize IT infrastructure and terminology on a national level. These projects are targeting not only radiology, but all of healthcare, with the final goal being a national system providing access to all medical records. Several issues are still to be resolved, but there is a common goal of having such a system in the future.

Both Swedish hospitals in this study, were using advanced technology in terms of HIS, RIS, PACS, Digital modalities and a module for rounds. One of the hospitals also used a teleradiology service in Spain, helping the radiology department deal with the shortage of radiologists in Sweden. The same hospital was also starting to evaluate the usage of a voice recognition system, to help speed up the final reports. Both hospitals were part of the region of VGR, where the project to get a system that would connect all radiology departments within the region, was in the process of being acquired.

The Swedish hospitals were using IT for two activities that were different from the US, the 'rounds' module, developed by a Swedish RIS/PACS vendor (Sectra), that provided functions for the rounds conducted at Swedish radiology departments, and the project of connecting all radiology departments within a region, for loadbalancing between hospitals.

At the community hospital in the USA, they where not using IT as extensively as in Sweden and did not yet have PACS, which meant that they were still printing images that had to be archived in large file-rooms. Despite this, they were using IT in a creative way. The modalities they had that were digital (MR and CT), made it possible for them to have a radiologist reading images in Australia during the nights, making it easier to attract radiologists to the hospital.

The pediatric hospital was using technology the most extensively, with well integrated systems and not printing any film at all. They used a voice recognition system that had increased their efficiency, and they were happy with the system. They had a group of radiologists from a radiologist corporation doing the reading off site during the night, making it possible for them to be specialized and maintain a high quality. It also meant that the radiologists had a more predictable and social work environment at night.

Also, in the USA, there was an ongoing process of standardizing terminology on a national level, and just like in Sweden it was a slow process, with lots of issues to resolve.

Discussion

The purpose of this thesis was to find out how IT was used strategically, at radiology departments in Sweden and USA. To understand radiology in a business context, a brief description of radiology was presented.

Radiology functions as a service for other doctors in healthcare. There are two separate Value Systems[58] (figure 11), the one within the hospital (inpatient) and the one for patients outside the hospital (outpatient). It was the same situation for the studied departments in both Sweden and the USA.

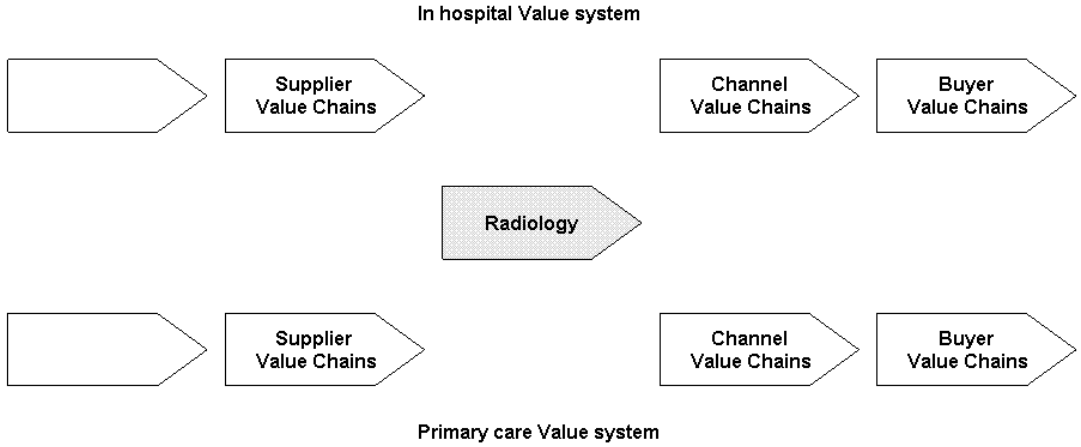
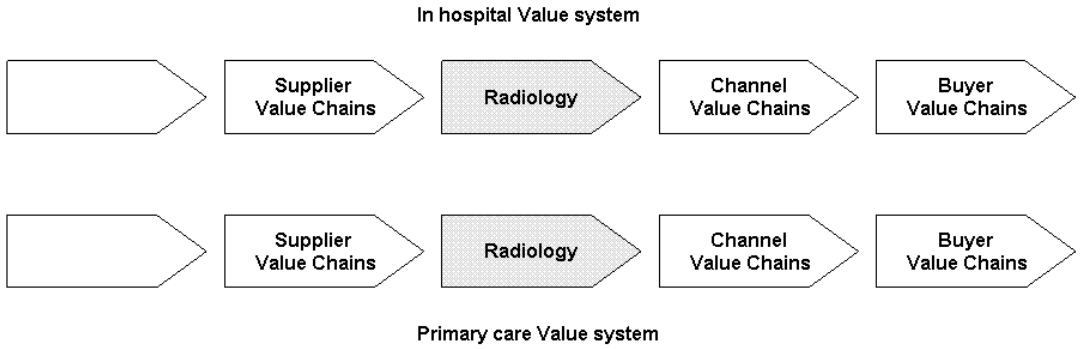


Figure 11 Radiology Value System today

When looking at radiology as a part of the Value System within the hospital, radiology must follow the business strategies of the hospital, thereby not being able to position themselves differently from the hospital in general.

On the other hand, when looking at radiology as part of the Value System of providing a service for doctors outside the hospital, it would be possible for them to position themselves freely, in a way that would be beneficial for them business wise. A possible development (figure 12) in the future could be smaller radiology departments focusing on outpatient exams, making it possible for them to stay open only during the daytime, and to specialize in particular types of exams. It might be possible only in the larger cities where there are a greater number of patients.

[58] See section on Porter



Figur 12 Possible Radiology Value System in the future

The radiology departments in this study, were part of hospitals that had positioned[59] themselves in slightly different ways. The Swedish hospitals, were both part of the public healthcare system, where the patients mainly come from a geographic area around the hospital, just like the community hospital. The pediatric hospital on the other hand, was specialized in providing care to children (pediatric care), choosing a particular group of patients, not necessarily located in the geographic area around the hospital.

When looking at the region where the two Swedish hospital were located, the region was working hard with increased operational effectiveness at each individual radiology department, but they where also trying to make the whole region more effective by cooperation between the hospitals, by loadbalancing work through use of IT. The hospitals did not need to compete amongst themselves, since they were all part of the same organization and automatically had the patients in the region.

It was a bit different with the corporation that owned the community hospital. Even though the hospital was targeting the 'local' region, the corporation had a strategy of keeping costs low, by having the same information systems at all hospitals. That way they were able to keep licensing fees and support costs down. The study did not show that they where looking at any possible benefits by connecting the systems, like the Swedish region.

The conditions were different at the pediatric hospital. They were not part of a corporation or any public region, therefore they could make decisions by themselves, giving them the advantage to implement new technology very fast. The hospital was clearly specialized in pediatrics, as was the radiology department. As such they were also focused on insuring high quality and efficient technology.

It was interesting to see that they had outsourced the core activity of the radiologists to another company. Even though it clearly benefited the radiology department, by having specialized radiologists, it was opposite what most other industries do.

[59] See section on Porter

This study showed that the way radiology was working in the departments, was very similar between all the hospitals, with the difference that the community hospital was not as well developed regarding the digital technology. Still, the hospitals differed in their approach to technology and their use of information systems.

As Porter described the competitive advantage of technology and productivity, there had to be some sort of differentiation in the way an organization operates, to give them a competitive advantage. When technology develops, Porter believes that there is a 'productivity frontier' of best practices, which forces organizations to stay up-to-date, in order to stay in business.

In this study, the technological development in radiology was studied to determine the productivity frontier in the business of radiology. To understand this development, the way of integrating information systems was studied, and the work being done to benefit from this development.

In radiology there has been a continuous fast development of information systems and technology being used, and a series of benefits has been achieved through the use of IT.[60] To achieve the best benefits of the technology, standardized interfaces between systems have been developed, and are used in most systems today. The development of the technology is being done on an international level and most information systems are built on the same platform in all countries, providing the same standard and built-in 'best practice', even if they differ from one vendor to another.[61] Most radiology departments today use the digital technology, with the built in standardized interfaces between the systems, and the interoperability between systems keeps getting better and better. Prices are also dropping, making it more and more profitable to acquire the technology. Therefore, the productivity frontier is driven by this development, and this study shows that it is necessary to use the available technology to stay competitive.

There is also work being done, in both Sweden and the USA, to standardize terminology being used in healthcare in general, which must be done in order to connect systems and hospitals on a larger scale. The governments in both countries have appointed organizations for this work on terminology, but the projects have many stakeholders and will take a long time, before any benefits from the work can be seen.

The empirical results show that despite different levels of IT usage at the hospitals, they all used the new information technology in some way to solve practical issues.

- In Sweden, one of the hospitals used a radiology service provided by radiologists in Spain, solving the problem of a shortage of radiologists in Sweden. In addition, the radiology departments in the region, were planning

[60] See section on benefits of PACS
[61] Interview with representatives for RIS/PACS vendors Agfa and Sectra

on getting connected through a system, that would provide the opportunity for loadbalancing between the hospitals, making them more productive. The Swedish hospitals also used a 'rounds module' designed specifically for the needs in the Swedish hospitals, making their workflow more efficient and providing better learning opportunities for radiologists and referring doctors.

- At the community hospital in the USA, they used a 'nighthawk' service, provided by a radiologist in Australia, helping the hospital to attract radiologists (which was a problem), since they did not have to work so many nights.
- The pediatric hospital used a group of radiologists, who had their own corporation, with a central reading room, where they were reading images from many hospitals at night, making it possible to schedule night work, and to always have at least two radiologists working together. By having so many radiologists in the corporation, they could also specialize in their own field, providing higher quality.

So how strategic were the departments use of technology?

The technology that provides the opportunity for 'teleradiology', where the radiologist is physically in a different location than the patient, really is the digital imaging technology. This digital technology is available for any radiology department (even though it is still costly), making it a technology that is necessary, instead of providing a competitive advantage.

At the pediatric hospital, there was a group of radiologists, who used the technology to work in a slightly different way, making it possible for them to become more specialized and to provide a higher quality in their work. It is not the technology itself making them more specialized, but the way they are using the technology. It should be possible for competitors to use the same technology and gain the same benefits, but it would take time to build the collective knowledge of this group.

In Sweden, the radiology departments were in the process of getting a system that would make it possible for them to loadbalance, and share the reading of images. It was a process open to the public, so any competitor would be able to do the same, but the region had a benefit of being so large, making it harder for smaller, private radiology departments to gain the same benefits.

The real beneficiaries of this technological development ought to be the society as a whole, i.e. the countries. Especially in Sweden where it is possible to take advantage of the public healthcare, to gain benefits for the general public. In the USA, it is also the society that benefits from the technological developments, but there are issues in coordinating the process between the hospitals, and discussion about who should take the cost of necessary investments.

It seems that Carr is somewhat right, in his provocative article, where he believes that the society is the main beneficiary of the technological developments in IT, and that there are other factors, besides just the use of IT, that makes an organization competitive.

Conclusion

Radiology is in a great deal of change and it is uncertain how it will change in the next few years, but the radiology departments are definitely on the bleeding edge of technological development. Other institutions in healthcare are likely to experience similar changes with (hopefully) significant increases in operational effectiveness.

All radiology departments in this study indicate an increase in operational effectiveness with the use of IT. Most employees also preferred the use of the digital technique and there were many similarities between the radiology departments in Sweden and the USA. The productivity frontier in radiology is moving outward fairly fast, with the use of new technology, and the radiology departments in this study are working hard to stay with the frontier. Much work is done to standardize integration of computerized systems, and in both Sweden and the USA there are organizations working with the standardization of the conceptual model across the nation.

There are ongoing projects developing a common use of terminology across the nations, but also within smaller groups, like the group of radiologists servicing the pediatric hospital. This will mostly benefit the society as a whole, meaning the countries, and all healthcare when the information domain is growing.

Even though radiology functions partly as a service provider for referring doctors within the hospital and partly for referring doctors outside the hospital, the department is a function within a larger organization and the strategic decisions are made by management at the hospital level.

Some use of IT at the studied departments, was not intended to increase the operational effectiveness, but were not likely to be considered of strategic importance to get a sustainable competitive advantage. Instead, they were of more practical/tactical nature, in that they resolved some practical issue for the departments.

The fast moving productivity frontier, and the integration of information systems, together with the integration with other parts of healthcare, mainly benefit the countries, instead of providing any sustainable competitive advantage to the individual radiology departments or hospitals. This is consistent with what Carr says in 'IT doesn't matter', where he means that the use of IT does not provide any strategic value, but is a necessity to stay in business.

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Interviews and meetings

Interview with manager A at Swedish hospital 2004-12-06 and 2005-12-18
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Interview with radiologist K at Swedish hospital 2005-02-23

Interviews with manager D at community hospital 2005-02-17 through 2005-03-12
Interview with manager E at community hospital 2005-02-21
Interview with radiology technician at community hospital 2005-02-18

Interview with PACS administrator at pediatric hospital 2005-01-07 and 2005-03-21
Interview with radiologist M at pediatric hospital 2005-03-23

Interview with representatives for RIS/PACS vendors Agfa and Sectra 2005-01-31 and 2005-02-10
Interview with Inger Weijerfelt, InfoVU 2005-01-16
Interview with Gilbert L. (previous board member at community hospital)2005-02-23
Meeting with DRA i VGR 2004-12-06 and 2005-01-14

Appendix - Abbreviations

ADT	- Admittance, Discharge, Transfer
CR	- Computed Radiology
CT	- Computer Tomography
DICOM	- Digital Imaging
DR	- Digital Radiology
DRA	- Distribuerat Radiologiskt Arbete (Distributed Radiological Work)
HIMSS	- Healthcare and Information Management Systems Society
HIS	- Hospital Information System
HIPAA	- Health Insurance Portability and Accountability Act
IHE	- Integrating the Healthcare Enterprise
HL7	- Health Level 7
IS	- Information System
IT	- Information Technology
MRI	- Magnetic Resonance Imaging
NCVHS	- National Committee on Vital and Health Statistics
PACS	- Picture Archiving and Communication System
PET	- Positron Emission Tomography
RIS	- Radiology Information System
RSNA	- Radiology Society of North America
SNOMED	- Systematized Nomenclature in MEDicine
VGR	- Västra Götaland Regionen (the Region of Västra Götaland)